seems small in comparison with those of our own large museums; there is a special fund, *Matice Ceskā*, for the publication of scientific works in the Bohemian language, and another for the continuation of Barrande's great memoirs on the Silurian of Bohemia. There were 91,000 visitors and it is stated that of the Museum Guide Book, 555 copies in German were sold and 1,008 in Bohemian.

The report of the West Prussian Provincial Museum which, as its name indicates, is actively concerned with the history of that region including archeology, ethnology, and natural history, is mainly devoted to detailed accounts of the numerous accessions received by the different departments. These notices contain much information regarding the various objects, for example, noting the past and present range of the bear and wild boar, and describing and figuring various archeological specimens and the conditions under which they were found.

The Glasgow, Edinburgh and Norwich Castle Museums all include art galleries, and the report of the former relates to four distinct institutions. In all of these, science is necessarily more or less subordinated, playing the most important part perhaps in the Norwich Museum, and all are exhibition museums, none of them issuing any publications save guides to the collections. That of Norwich is particularly good and contains much information, especially in regard to the valuable local collection of birds. The attendance for these institutions was respectively 1,210,648; 770,807 of this being at 'The People's Palace,' 338,287 and 128,969.

The Manchester Museum is, if Mr. Hoyle will pardon the phrase, a very live Museum, and the report opens with a brief notice of the installation of the electric light. This was described at some length in the Report of the Museums Association of Great Britain, and comprises 162 incandescent and 44 arc lights, the latter of the inverted type and with the light reflected not downwards, but by means of a conical reflector upwards to the white ceiling. The most important acquisition has been the Dresser collection of birds, noticed in SCIENCE, and the most important publication, Mr. C. D. Sherborne's 'Index to the Systema Naturæ of Linnæus,' showing the place of every species name in the tenth and twelfth editions both as to genus and page. Mr. Sherborne is a believer in the 'law of priority' as applied to nomenclature and indicates his preference for making the tenth edition its starting point.

The number of gifts to these various museums, governmental or local, is noteworthy, since this is largely a test of the interest taken by the community in the welfare of the institution, but it is to be remarked that ethnological material is less freely given than any other. Finally three of the museums present us with figures bearing on the question of Sunday opening, and in each case the number of visitors on Sunday is much in excess of that on other days; thus in the Australian Museum, the average week day attendance was 341, that of Sunday 634, while in the Norwich Museum, the figures were respectively 396 and 706. At the Manchester Museum the attendance on week days ranged from 30 to 372 and on Sunday from 146 to 550.

F. A. L.

ROBERT WILHELM BUNSEN.

WITH the death of Bunsen there has passed away the last of those great German chemists of the middle of the present century, chemists who bore the greatest part of the work of laying the foundations of the modern science, and through whose efforts their fatherland has taken the first place in chemistry among the nations of the earth. The century began with Wöhler and Liebig; in the next decade came first Bunsen

and then Hofmann and Kolbe and Fresenius; perhaps to these we should add Kekulé, who followed ten years later. Wöhler brought to Germany the chemical power and intellect of the Swede Berzelius; Liebig the brilliancy of the French school, where Gay-Lussac, Vauquelin, Thénard, Dulong, Chevreul and other successors of the 'Father of Chemistry' were full of activity. Wöhler, at Göttingen, and Liebig, at Giessen, became the progenitors of the German school. Bunsen and Kolbe were Göttingen boys, Hofmann and Fresenius (and we might add Kopp) were born at Giessen, while Kekulé was a youth in Bunsen's laboratory. This band of men were not merely discoverers of chemical fact and theory; they were the discoverers of men. Hardly a chemist of note to-day in Germany or England or America, who has passed young manhood, but has felt the direct impress of one or another of these men. They have been the world's teachers of chemistry, and to-day how many teachers are using their personal recollections of these their own instructors to inspire the next generation of pupils.

And now the last of these giants is gone. Liebig was the first to be taken, just rounding out his three score years and ten. A decade later and Wöhler and Kolbe passed. The last ten years have seen the death of Hofmann, Kekulé, Fresenius and now, at the close of the century, a few months only before the hundredth anniversary of Wöhler's birth, Bunsen is dead.

The outward incident of Bunsen's life is quickly told. Robert Wilhelm Bunsen, the son of a distinguished theologian, was born at Göttingen, March 31, 1811. In 1831 he was graduated at the University of Göttingen as Ph.D., and after some study at Paris, Berlin and Vienna he was appointed *Privatdocent* and then assistant professor at Göttingen. In 1836 he succeeded Wöhler at the Polytechnic School at Cassel, and in 1838 was appointed professor of chemistry at Marburg. Here he remained for several years, went to Breslau for a short time, when he was called in 1851 to Heidelberg. Here he remained active till 1889, when he resigned from service; but he still retained all his old interest in the chemical laboratory. Sometime before resigning, he received a very urgent call to the University of Berlin, but he was unwilling to change his home in his old age. He died at Heidelberg, August 16, 1899. Few honors which fall to the lot of chemists but were bestowed upon him. In 1858 he was elected foreign member of the Royal Society; in 1883, one of the eight foreign associates of the French Academy of Sciences. He received from the Royal Society in 1860 its Copley medal, and in 1877 he and his associate Kirchhoff were joint recipients of the newly-founded Davy medal.

Bunsen was a broad chemist, confining his work to no one branch of the chemical field. He was equally at home in theory and in practice, and perhaps his most important work consisted in laying foundations on which others should erect the superstructure. He would hardly be called a prolific writer, and yet he is credited with more than a hundred articles, of most of which he was the sole author.

His first published work was in 1834 and consisted of a short note in the *Journal de Pharmacie* calling attention to the value of ferric oxid (hydrated peroxid of iron) as an antidote for arsenic poisoning. This was the beginning of his work on arsenic, from which he was to receive great reputation, but from which also he was to nearly lose his life. He could not have better shown his pluck and enthusiasm than by attacking the dangerous problem of the organic compounds of arsenic. It was a theme which has cost more than one chemist his life, but it was of great importance in Liebig's work on the 'radical theory.'

More than twenty years earlier Berzelius had said: "The application of what is known regarding the combination of the elements in inorganic nature, to the critical examination of their compounds in organic, is the key by which we may hope to arrive at true ideas with respect to the composition of organic substances." Bunsen followed up this idea, showing that the so-called *alkarsin*, $As_2(CH_3)_4$ was a radical, but a compound radical, being made up of arsenic an inorganic element combined with hydrocarbon radicals which are organic. This work of Bunsen's, though of course far less reaching in importance than Wöhler's then recent synthesis of urea, was far more difficult and dangerous, not only than this, but also than Liebig and Wöhler's investigations of the benzoyl radical and Gay-Lussac's study of the cyanogen radical. This work of these four chemists established for the time being the 'radical theory' which indeed was to be soon overthrown, but was later to reappear as a part of our theory of to-day.

At the time Bunsen was carrying on his researches on organic compounds of arsenic, he was beginning that series of investigations on the gases in the iron furnace, which culminated in the report presented to the British Association in 1845 by himself and Lord Playfair, on the 'Gases evolved from iron furnaces, with reference to the theory of smelting of iron.' While the utilization of the waste gases of the iron furnace for fuel had been attempted at a much earlier date, it was not till the work of Bunsen, alone and with Playfair, that the enormous waste in these gases was impressed upon iron-masters; so that Bunsen can be said to have largely contributed to this great source of economy in the modern furnace. In other directions also these investigations bore practical fruit.

The study of furnace gases had demanded methods of gas-analysis which at that time did not exist. Perfecting the old, originating new, Bunsen built up a system of methods of gas analysis which have remained the foundation of those subsequently used; indeed he has been called the founder of this branch of analytical chemistry.

In this connection should be mentioned the Bunsen burner, now universally used in chemical laboratories, and almost as extensively outside, as in the Welsbach light. The principle of mixing a proper amount of air with a combustible gas and burning it from an open tube is very simple—after it is known, but it was unknown until discovered by Bunsen.

In 1841 and 1842 Bunsen published his experiments on the use of carbon in the place of the more expensive platinum in the Grove battery. The outcome of this work was the Bunsen battery, which has been one of the most useful as well as the cheapest of all batteries, and which may be said to have refused to yield supremacy until displaced with all other batteries by the dynamo.

Having a powerful source of electricity at his disposal, he re-investigated the methods by which nearly fifty years before Davy had been the fortunate discoverer of so many new elements. Bunsen improved these methods, and made in connection with Matthiessen, the first thorough study of lithium, which had been discovered by Arfvedson in 1817, and for the first time the metal was isolated by him.

All through this period and for many years later he took great interest in mineralogical chemistry, especially in the chemistry of rock formation. In 1847 he visited Iceland, and soon after published a number of papers on the chemical geology of that island and also on the theory of geysers.

A series of investigations carried out with Sir Henry Roscoe, on photo-chemistry, laid the foundations of actinometry. The work of Daguerre and his followers had

just given birth to the art of photography, but the whole subject was up to this time empiric. By Bunsen and Roscoe it was placed on a scientific basis and the way blazed out for the many future investigators in this field.

One further study should be mentioned, that of Bunsen and Schischkoff on the theory of gunpowder. Gunpowder had been known for centuries; van Helmont had stated that its power was due to the production of gas, but beyond this little or nothing was known till these chemists took up the investigation of the gases formed and the powder residues, and formulated for the first time a theory of gunpowder. Here as in other cases the first incentive was given which resulted in the work of Karolyi and Abel and Nobel, and the many present-day workers in the field of explosives.

This *résumé* is but an outline of the more important work of this great chemist, during the first half century of his life. It was almost at the close of this half century that there was to come, as it were as a crown to his work, that great discovery with which the name of Bunsen will ever be most closely linked, spectrum analysis. For several years he had been interesting himself much in blow pipe analysis, and it seems probable that the key to this discovery came, not as a result of long and patient search, but rather grew from his daily work of laboratory instruction. It was the discovery of the teacher rather than of the investigator. Associating with him his colleague, Kirchhoff, together they worked out the practical application of his discovery, and science stood armed with a new weapon, the spectroscope. Bunsen was the first to avail himself of the instrument and brought forth from the waters of Dürkheim two new elements, rubidium and cesium. Later other new elements have followed, as indium discovered by Boisbaudran and thallium by Crookes, and a host of 'meta elements' differentiated only by the spectroscope, the latest of them, victorium, needing not only this instrument but also the camera, to render its 'lines' apparent.

But far more important than the mere discovery of new elements was the widening of man's horizon in a new and unexpected way. Spectrum analysis was applicable not alone to those flames we could place before it within the confines of our laboratories; the light of the sun and the stars could be studied equally well and a means was at hand for learning the chemistry of the heavenly bodies. Yet this was not all, for by the displacement of lines the motion of stars and other bodies in line of sight becomes known. Astro-physics is rendered possible by Bunsen's work.

The last of the great investigations of Bunsen were on calorimetry. The Bunsen ice calorimeter was described by him in 1870 and rendered possible specific heat determinations, with quantities hitherto too small for investigation. While from this time his activity was much lessened, yet now and then papers continued to appear from his pen. The last few years of his life, however, were spent in the quiet retirement of the old university town which had so long been his home. As long as he was able he took great delight in showing visitors over his old laboratory, and the writer will long remember a pleasant hour spent with the old man in his laboratory some years ago, how he showed the rooms and places where this or that historic work was done, and what a delightfully genial man he was to a young stranger.

As the old chemist's sun was sinking to the west there came to Heidelberg, like a brilliant meteor, one whose fame far outshone the older light. All things were changed, the old building passed, a new and magnificent laboratory took its place; again students flocked to the Neckarthal

for chemical study, but the discoverer of the spectroscope was almost forgotten. A few brief years passed by, and as the light of the brilliant meteor is suddenly extinguished, so Victor Meyer was no more. But still Bunsen lingered, as if loath that a single year of the century ushered in by his master Wöhler should be left without the presence of one of the giant minds of chemistry. But now he too is gone and the last link between the past and the present is severed as far as lives go; but upon the foundations laid by Bunsen many a superstructure will continue to rest, and yet many another building will be erected.

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SCIENTIFIC BOOKS.

Anatomie des Frosches auf Grund eigener Untersuchungen. By A. ECKER und R. WIEDERSHEIM, durchaus neu bearbeitet von DR. ERNST GAUPP. Zweite Abteilung, Zweite Hälfte. Lehre vom Gefässsystem. Braunschweig, 1899, pp. XII. and 237–548.

Some time ago (this JOURNAL, Vol. VII., p. 463) we had occasion to notice the first and second parts of Gaupp's edition of Ecker on the frog, and now the third part of the same work lies before us. This part is devoted solely to the anatomy of the vascular system and here, as in the sections devoted to the skeleton, muscles and nerves, we find what is practically a new treatment, and not merely a revision of an old work. Not only has every page been rewritten, but every illustration has been redrawn, and most of them are printed in colors, adding not a little to the clearness.

It is impossible to summarize these 312 pages nor to point out what is new in them, for that would require more space than we can give. As one would naturally expect, the additions and changes are less in the parts relating to the arteries and veins, but even here they are numerous. The heart is described with far more accuracy and detail than ever before. It is, however, in the lymph system that the changes are the greatest. In fact, this section is almost wholly a new investigation. In the former editions there was a brief account of the lymph-hearts and of some of the sub-cutaneous lymph-sacs and that was all. Dr. Gaupp has studied not only all of these (he has added four sub-cutaneous lymph sacs not recognized before), but he has described with the greatest detail the lymph spaces which are scattered through the body and has made out the openings by which they communicate with one another.

As we turn over the pages of the work we wonder what the technique has been and many may be glad to learn his methods. For injections of the arterial system he found that shellac solutions were most useful, while for the venous system he depended largely upon natural injections, the blood settling in these vessels. To aid in this the animals were hung in various positions so that the blood might flow into the various portions. Then a transfer to formalin produced coagulation. A similar coagulation of the lymph as well as the well-known method of inflation with air aided in the demonstration of the lymph sacs and spaces; while the communications between these (minute openings in the thin and almost transparent membranes) were rendered visible by means of absolute alcohol and weak solutions of iodine.

In conclusion we may say that we have only praise for this part of the work, and that, while in a few places we find differences from conditions which occur in our American frogs, we find nothing that we can regard as serious errors. The probabilities are that it will never be translated, but it is a treatise which should be on the shelves of every laboratory. The clear and simple German in which it is written will make its contents easily accessible to the great majority of our college students. The concluding part dealing with the viscera, integument and sense organs, is promised shortly.

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The Fixation, Staining and Structure of Protoplasm, a Critical Consideration of the Theory and Technique of Modern Cell-study. By DR. ALFRED FISCHER (Leipsic), royal octavo, 362 pages, 1 double plate and 21 figures in text. Published by G. Fischer, Jena, 1899.

The history of the closing cycle of botanical